

Springer Series on Environmental Management

James S. Latimer · Mark A. Tedesco
R. Lawrence Swanson · Charles Yarish
Paul E. Stacey · Corey Garza *Editors*

Long Island Sound

Prospects for the Urban Sea

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Contents

1 Long Island Sound: A Socioeconomic Perspective	1
Marilyn E. Weigold and Elizabeth Pillsbury	
2 The Geology of Long Island Sound	47
Ralph Lewis	
3 The Physical Oceanography of Long Island Sound	79
James O'Donnell, Robert E. Wilson, Kamazima Lwiza, Michael Whitney, W. Frank Bohlen, Daniel Codiga, Diane B. Fribance, Todd Fake, Malcolm Bowman and Johan Varekamp	
4 Geochemistry of the Long Island Sound Estuary	159
Carmela Cuomo, J. Kirk Cochran and Karl K. Turekian	
5 Metals, Organic Compounds, and Nutrients in Long Island Sound: Sources, Magnitudes, Trends, and Impacts	203
Johan C. Varekamp, Anne E. McElroy, John R. Mullaney and Vincent T. Breslin	
6 Biology and Ecology of Long Island Sound	285
Glenn Lopez, Drew Carey, James T. Carlton, Robert Cerrato, Hans Dam, Rob DiGiovanni, Chris Elphick, Michael Frisk, Christopher Gobler, Lyndie Hice, Penny Howell, Adrian Jordaan, Senjie Lin, Sheng Liu, Darcy Lonsdale, Maryann McEnroe, Kim McKown, George McManus, Rick Orson, Bradley Peterson, Chris Pickerell, Ron Rozsa, Sandra E. Shumway, Amy Siuda, Kelly Streich, Stephanie Talmage, Gordon Taylor, Ellen Thomas, Margaret Van Patten, Jamie Vaudrey, Charles Yarish, Gary Wikfors and Roman Zajac	

7 Synthesis for Management 481
Mark A. Tedesco, R. Lawrence Swanson, Paul E. Stacey,
James S. Latimer, Charles Yarish and Corey Garza

Glossary 541

Index. 553

Chapter 3

The Physical Oceanography of Long Island Sound

**James O'Donnell, Robert E. Wilson, Kamazima Lwiza, Michael Whitney,
W. Frank Bohlen, Daniel Codiga, Diane B. Fribance, Todd Fake,
Malcolm Bowman and Johan Varekamp**

3.1 Introduction

The ecology and geochemistry of Long Island Sound (LIS) are strongly influenced by the physical processes that determine the spatial structure and temporal evolution of the temperature (T), salinity (S), and DO concentrations and the distribution of the sediments. Much has been learned about these processes in the last decade through a combination of theoretical work, process studies, and the analysis of archived observations. The first wide-ranging summary of physical processes in LIS was published in 1956 by the Peabody Museum of Natural History at Yale University. Though the collection of papers mainly addressed biological oceanography, the chapter by Riley (1956) described the basic structure of the hydrography, tides, and currents, and much of his insight remains relevant. For the more general reader, Koppelman et al. (1976) provided a broad overview of the geological origin and geomorphology of LIS and summarized major characteristics of weather and climate. There has not been an extensive review of the literature since then. Reviews of the physical processes in neighboring water bodies are available.

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In particular, the hydrography and circulation of the Middle Atlantic Bight are summarized by Mountain (2003) and Lentz (2008). A review of Block Island Sound (BIS) and Rhode Island Sound physical oceanography is given by Codiga and Ullman (2010) and corroborated and augmented with recent observations by Ullman and Codiga (2010). The physical processes in the Hudson River are summarized by Geyer and Chant (2006).

We begin with a description of the characteristics of the phenomena that have significant influence on the hydrography and circulation: the freshwater discharge, the wind and wave climate, and the tides. In Sect. 3.2, we then describe the evolution (on time scales longer than tidal) and structure of the T , S , and density distributions in the Sound using a broad array of datasets. The magnitude and structure of the residual circulation are summarized in Sect. 3.3 and evidence for seasonal variations is summarized in Sect. 3.4. In Sect. 3.5, we discuss the effects of wind on sea level and circulation. In Sect. 3.6, we review recent observational and theoretical work on the physical processes that influence the duration and extent of hypoxia. Hypoxia, low concentrations of DO, develops in the deeper waters of the western Sound every summer and the impacted region spreads eastward as summer progresses. The data records resulting from water quality monitoring programs are now several decades long and in Sect. 3.7, we summarize some characteristics of long-term changes that can be detected. In Sect. 3.8, we outline the characteristics and magnitude of the response of the Sound to severe storms and comment on the likely impact of climate change. In the final section, we summarize and comment on the main results of the review.

3.1.1 Freshwater and Saltwater Sources

LIS is often described as an estuary because it is significantly fresher than the adjacent shelf water of southern New England. But it is an atypical mid-latitude estuary in several ways. First, it is unusual that the largest freshwater tributary discharges into the estuary near the main connection to the ocean. Gay et al. (2004) summarized the long-term average discharge of the seven rivers entering the Sound (see Table 3.1). The Connecticut River is the dominant source of fresh water and contributes 75 % of the total gauged discharge. Gay et al. (2004) also pointed out that there is a distinct seasonality to the flow rates. Since the extensive watershed of the Connecticut River includes the mountains in New Hampshire and Vermont, which accumulate precipitation as snow and ice throughout the winter, there is a large freshet in the spring. Figure 3.1 shows that the mean monthly flow in March, April, and May all exceed the annual average flow and the mean April discharge is more than twice the average.

The mechanisms that lead to dispersal of the effluent from the Connecticut River are quite complex. This was the subject of a series of reports by Garvine (1974, 1975 and 1977). With ship surveys and drogue studies, he showed that a large area of ELIS was covered by a thin (2 m) surface layer of brackish water that